<u>RTCA Special Committee 186, Working Group 3</u>

<u>ADS-B 1090 MOPS, (DO-260), Revision B</u>

<u>Meeting #18</u>

<u>Teleconference 01.21.04</u>

Proposed Change for Global Decoding of the ES Surface Format

(Prepared originally by the SCRSP TSG)

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SUMMARY
The material in this Working Paper was originally presented to the Surveillance and Conflict Resolution Systems Panel (SCRSP), Working Group B, Technical Subgroup, and presented by Kojo Owusu as Working Paper WP/B/6-05, as a proposal to change the 1090 ES SARPS. In the text of this Working Paper references to SARPS have been changed to MOPS, and other editorial changes as needed to convey the message of change to DO-260A. Experimental data from Australia indicates that global decoding of Extended Squitter Surface Position reports may be required in certain applications. In Appendix A of the current MOPS, compact position reporting (CPR) does not define the technique to be used for surface format global decoding. This working paper specifies a technique for performing global decoding on ES surface position messages and proposes that it be added to the next revision of the 1090 MOPS (DO-260B).

1.0 Background

Experimental data from Australia indicates that global decoding of ES surface position reports may be required in certain applications. In Appendix A of the current MOPS, compact position reporting (CPR) does not define the technique to be used for surface format global decoding.

2.0 Proposed MOPS Revision.

It is proposed that the technique for CPR global decoding of the surface format defined below be added to the CPR definition contained in Appendix A, as section A.1.7.8.

Add the following new material as section A.1.7.8, and renumber the existing paragraph to A.1.7.9:

A.1.7.8 Globally Unambiguous Surface Position Decoding

This algorithm **shall** utilize one CPR surface position encoded "**even**" format message together with one CPR surface position encoded "**odd**" format message, to regenerate the geographic position of the aircraft or target.

As surface-format messages are initially received from a particular aircraft, if there is no prior history of this aircraft, then a global decode **shall** be performed using even and odd format receptions, as described in this section.

<u>Note 1:</u> *If the aircraft has been transmitting airborne format messages and their receptions were in-track, then it is not necessary to use even-odd decoding. Beginning with the first individual surface message reception, the location can be decoded using the local-decode technique, based on the previous target location as the reference.*

<u>Note 2:</u> *Even if the aircraft is appearing for the first time in surface format receptions, any single message could be decoded by itself into multiple locations, one being the correct location of the transmitting aircraft, and all of the others being separated by 90 NM or more from the correct location. Therefore, if it were known that the transmitting aircraft cannot be farther away than 45 NM from a known location, then the first received message could be decoded using the locally unambiguous decoding method described in Section 2.6.6. Under some circumstances it may be possible for an aircraft to be first detected when it is transmitting surface position messages farther than 45 NM away from the receiving station. For this reason, even-odd decoding is required when messages are initially received from a particular aircraft. After this initial decode, as subsequent messages are received, they can be decoded individually (without using the even-odd technique), provided that the intervening time is not excessive. This subsequent decoding is based on the fact that the aircraft location has not changed by more than 45 NM between each new reception and the previously decoded location.*

The even-odd decoding process **shall** begin by identifying a pair of receptions, one in the even format, the other in the odd format, and whose separation in time does not exceed 25 seconds.

Note: *The limit of 25 seconds is based on the possible change of location within this time interval. Detailed analysis of CPR indicates that if the change of location is 0.75 NM or less, then the decoding will yield the correct location of the aircraft. To assure that the change of location is actually no larger, and considering the maximum aircraft speed of 100 kt specified for the transmission of the surface format, the combination indicates that 25 seconds will provide the needed assurance.*

Given a CPR 17-bit surface position encoded in the "**even**" format (*XZ*0, *YZ*0) and another encoded in the "**odd**" format (*XZ*1, *YZ*1), separated by no more than 25 seconds, the algorithm shall regenerate the geographic position (latitude *Rlat*, and longitude *Rlon)* of the aircraft or target by performing the following sequence of steps:

a. Compute the latitude zone sizes $Dlat_0$ and $Dlat_1$ from the equation:

$$Dlat_i = \frac{90°}{60 - i}$$

b. Compute the latitude index:

$$j = floor\left(\frac{59 \cdot YZ_o - 60YZ_1}{2^{17}} + \frac{1}{2}\right)$$

c. Latitude. The following formulas will yield two mathematical solutions for latitude (for each value of i), one in the northern hemisphere and the other in the southern hemisphere. Compute the northern hemisphere solution of $Rlat_0$ and $Rlat_1$ using the following equation:

$$Rlat_i = Dlat_i\left(MOD(j, 60 - i) + \frac{YZ_i}{2^{17}}\right)$$

The southern hemisphere value is the above value minus 90 degrees.

To determine the correct latitude of the target, it is necessary to make use of the location of the receiver. Only one of the two latitude values will be consistent with the known receiver location, and this is the correct latitude of the transmitting aircraft.

d. The first step in longitude decoding is to check that the even-odd pair of messages do not straddle a transition latitude. It is rare, but possible, that $NL(Rlat_0)$ is not equal to

NL($Rlat_1$). If so, a solution for longitude cannot be calculated. In this event, abandon the decoding of this even-odd pair, and examine further receptions to identify another pair. Perform the decoding computations up to this point and check that these two NL values are equal. When that is true, proceed with the following decoding steps.

e. Compute the longitude zone size $Dlon_i$, according to whether the most recently received surface position message was encoded with the even format (i = 0) or the odd format (i = 1) :

$$Dlon_i = \frac{90°}{n_i}$$, where n_i is the greater of [NL($Rlat_i$ - i] and 1.

f. Compute m, the longitude index:

$$m = floor\left(\frac{XZ_0 \cdot (NL - 1) - XZ_1 \cdot NL}{2^{17}} + \frac{1}{2} \right)$$

where NL = NL ($Rlat_i$)?

g. Longitude. The following formulas will yield four mathematical solutions for longitude (for each value of i), one being the correct longitude of the aircraft, and the other three separated by at least 90 degrees. To determine the correct location of the target, it will be necessary to make use of the location of the receiver. Compute the longitude, $Rlon_0$ or $Rlon_1$, according to whether the most recently received surface position message was encoded using the even format (that is, with i = 0) or the odd format (i = 1):

$$Rlon_i = Dlon_i \cdot \left(MOD(m, n_i) + \frac{XZi}{2^{17}} \right)$$

where n_i is the greater of [NL($Rlat_i$ - i] and 1.

This solution for $Rlon_i$ will be in the range 0° to 90°. The other three solutions are 90°, 180°, and 270° to the east of this first solution.

To then determine the correct longitude of the transmitting aircraft, it is necessary to make use of the known location of the receiver. Only one of the four mathematical solutions will be consistent with the known receiver location, and this is the correct longitude of the transmitting aircraft.

Note: *Near the equator the minimum distance between the multiple longitude solutions is more than 5000 NM, so there is no question as to the correct longitude. For locations away from the equator, the distance between solutions is less, and varies according to the cosine of latitude. For example at 87 degrees latitude, the minimum distance between solutions is 280 NM. This is sufficiently large to* *provide assurance that the correct aircraft location will always be obtained. Currently no airports exist within 3 degrees of either pole, so the decoding as specified here will yield the correct location of the transmitting aircraft for all existing airports.*